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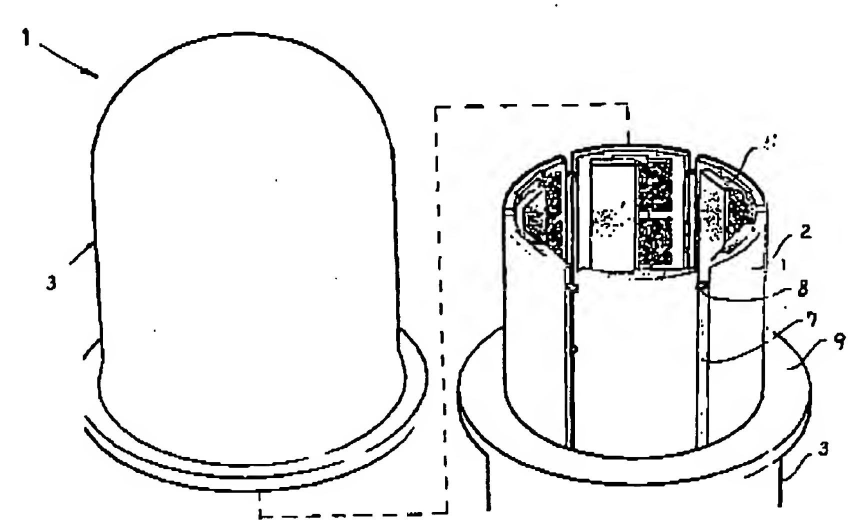
(54) Title: PASSIVE THERMAL TRANSFER OF SUBSEA ELECTRONICS



WO 01/13692 A1

(57) Abstract: A pressure vessel (1) for passive conduction of heat generated by current-carrying components (5) inside the vessel shell (3) is disclosed. The current-carrying components (5) are mounted to at least one heat conducting element (2), which at least one heat conducting element (2) is placed circumferentially against the inner wall (4) of the vessel shell (3). Each heat conducting element (2) has an outwardly facing surface (6) which is complementary to the internal wall surface of the vessel shell (3) and the outwardly facing surface (6) is in direct conducting engagement with the internal wall surface of the vessel shell (3), as passive conduction of heat only occurs.

WO 01/13692 A1

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

PASSIVE THERMAL TRANSFER OF SUBSEA ELECTRONICS

The present invention relates to a pressure vessel for passive conduction of heat generated by current-carrying components inside the vessel shell.

Electronics and electrical power components will always be associated with generation of heat. The heat generated will be detrimental to the performance and reliability of operation of the equipment if the heat is not dissipated by method of cooling either by natural or forced thermal transfer.

Cooling of electronics is normally achieved by either radiation/natural convection from a heat source to the surrounding ambient air, by utilising a fan for creating forced convection to the air or by transferring the generated heat by forced convection to a liquid that is pumped in a closed loop and dissipated in a heat exchanger.

Power distribution and control technology of oil and gas processing is currently in the process of being adapted to the subsea environment. This application requires the highest possible system reliability and availability due to the cost associated with retrieval, maintenance and production downtime.

Any components employed in addition to the primary components such as an auxiliary cooling system, will inherently cause failure at some point in time. To reduce the risk for failure, servicing will be required to maintain the reliability of operation. The system will also require space and thus adding weight and cost to the subsea package.

The subsea environment provides a natural heat sink since the temperature is low at water depths relevant for oil and gas production. The water will typically be about 4 degree Celsius and is constant.

Application of power distribution and control will require all the system components shielded from the seawater environment.

From US patent 4.184.539 is an electronic card mount and heat transfer assembly for underwater vehicles known. A plurality of electronic circuit cards are edge mounted in heat transfer relation to a pair of spaced parallel card mounting plates extending from a

bulkhead of an underwater instrumentation vehicle hull having a tubular cover section adapted to be moved into and out of covering relation to the cards and mounting plates. Spring biased slip plates provide heat transfer paths from the mounting plates to the cover section for dissipation to ambient water.

According to the invention, it is found feasible to have a passive cooling system as an integrated part of a subsea power distribution system, thus avoiding the added complexity associated with a utility cooling system.

This is achieved with a pressure vessel according to the introductory passage above, which is distinguished in that the current-carrying components are mounted to at least one heat conducting element, which at least one heat conducting element is placed circumferentially against the inner wall of the vessel shell and each heat conducting element has an outwardly facing surface which is complementary to the internal surface of the vessel shell and the outwardly facing surface is in direct conducting engagement with the internal surface of the vessel shell, as passive conduction of heat only occur.

For easy removal and replacement, the at least one heat conducting element can be expanded to the internal surface of the vessel shell without further fixing means. It is kept in place by means of the expanding effect of the element or elements only.

In one preferred embodiment is the at least one heat conducting element arranged with a gap in the longitudinal direction thereof and expanding means are provided in the gap and the expanding means are expanding the at least one heat conducting element outwardly and thus against the internal surface of the vessel shell.

In order to achieve best possible heat conduction, the at least one heat conducting element can be manufactured of any suitable thermal conductive material such as carbon-composite or aluminum.

For best possible performance, also the vessel shell can be manufactured of any suitable thermal conductive material like the following materials; carbon-composite, high-grade steel or titan.

To avoid possible air pockets or areas having little or absent contact, a gel, paste or similar can preferably be provided at the interface between the outwardly facing surface of the at least one heat conducting element and the internal surface of the vessel shell.

In one embodiment the vessel shell can have a cylindrical central part and a hemispherical part in each end. The vessel shell is, however, not limited to this external design, and can per se be oval, truncated cylindrical, parallelepipedic or of any suitable design.

The vessel shell can be bi divided and each part comprises a flange having means for securing the parts together.

In one embodiment the outer wall of the vessel shell can on at least portions of the surface thereof be provided with cooling promoting means, like cooling fins. Cooling fins will increase the manufacturing costs and will only be used when moore cooling is required.

Other and further objects, features and advantages with the present invent on will appear from the following description of a preferred embodiment of the invention, which is given for the purpose of description, without thus being limiting, and given together with the appended drawings, where:

Fig.1 shows a pressure vessel according to the invention with the one half of the vessel shell lifted off,

Fig.2 shows the assembly of the heat conducting elements and electronics. elctrical power components, and

Fig.3 shows a transversal cross section of the pressure vessel.

Fig.1 shows one embodiment of the pressure vessel 1 including a vessel shell 3 and internal heat conducting elements 2 to which the electronics and/or power components 5 are mounted. The illustrated vessel shell 3 has a design which comprises a cylindrical central section and a hemispherical section in each end. The vessel shell 3 is bidivided and each section has a circumscribing end flange 9 in the end opposite to the

hemispherical section. During assembly of the vessel 1, the flanges 9 are brought together and kept in sealing relation with each other by means of sealing means and fixing means like bolts or clamps around the flanges 9.

It is to be understood, however, that the design of the vessel shell 3 is not material and all suitable designs are possible, like truncated cylindrical, oval, parallelepipedic, etc. In addition, the outer surface of the vessel shell 3 may be provided with cooling promoting means, like cooling fins or similar means increasing the external surface area of the vessel 1.

This embodiment includes six heat conducting elements 2 extending in parallell in the longitudinal direction of the vessel shell 3. The elements 2 are placed circumferentially against the internal wall 4 of the vessel shell 3 and are spaced apart with a small longitudinal gap 7 therebetween. A number of springs 8 are mounted in the gap 7 between the heat conducting elements 2 thus expanding the heat conducting elements 2 outwardly against the internal wall 4 of the vessel shell 3. This expanding action is sufficient to keep the heat conducting elements 2 in place against the internal wall 4 of the vessel shell 3 without further fixing means. This makes installation and replacement of internal components 5 easy and convenient.

In another embodiment, fixing means may be provided to securely fix the heat conducting elements 2 to the internal wall 4 of the vessel shell 3. Also abutment means can be provided in the internal wall 4 of the vessel shell 3 to keep the heat conducting elements 2 in place in the longitudinal direction of the vessel 1.

The vessel 1 is designed to withstand the surrounding water pressure. High pressure penetration equipment allows for power supply and communication with the equipment within the vessel1.

The internal environment of the vessel 1 consists of an inert atmosphere maintained at low pressure.

Fig. 2 shows the electric components 5 generating heat assembled to an array of six cylindrical elements 2 or segments 2 made of a suitable conductive material, e.g.

carbon-fibre, aluminum, or any suitable material able to provide substantial thermal transfer.

The number of segments 2 can be from one and up. If only one is used, this need to have one longitudinal gap 7 in order to obtain the expanding action. The one or more segments 2 may or may not be arranged to fully circumscribe the cylindrical part of the vessel shell 3.

Fig.3 shows the intimate contact between the outwardly facing surface 6 of the segments 2 and the internal wall 4 of the vessel shell 3. The outer surface 6 of the segments 2 are arcuated to be coplementary to the curvature of the internal wall 4 of the vessel shell 3. It is material that the contact of the outer surface 6 of the segments 2 against the internal wall 4 of the vessel shell 3 is as extensive as possible.

In order to ensure this extensive contact, a gel, paste or similar having high heat conductivity may be coated on the outer surface 6 of the segments 2 or the internal wall 4 surface of the vessel shell 3. This improves the heat conduction and eliminates possible void spaces.

P a t e n t c l a i m s

1.

Pressure vessel (1) for passive conduction of heat generated by current-carrying components (5) inside the vessel shell (3), **characterised in that** the current-carrying components (5) are mounted to at least one heat conducting element (2), which at least one heat conducting element (2) is placed circumferentially against the inner wall (4) of the vessel shell (3) and each heat conducting element (2) has an outwardly facing surface (6) which is complementary to the internal wall surface of the vessel shell (3) and the outwardly facing surface (6) is in direct conducting engagement with the internal wall surface of the vessel shell (3), as passive conduction of heat only occur.

2.

Pressure vessel according to claim 1, **characterised in that** the at least one heat conducting element (2) is expanded to the internal wall (4) surface of the vessel shell (3) without further fixing means.

3.

Pressure vessel according to claim 1 or 2, **characterised in that** the at least one heat conducting element (2) is arranged with a gap (7) in the longitudinal direction thereof and that expanding means (8) are provided in the gap (7) and the expanding means (8) are expanding the at least one heat conducting element (2) outwardly and thus against the internal wall (4) surface of the vessel shell (3).

4.

Pressure vessel according to claim 1,2 or 3, **characterised in that** the at least one heat conducting element (2) is manufactured of carbon-composite or aluminum.

5.

Pressure vessel according to claim 1,2 or 3, **characterised in that** the vessel shell (3) is manufactured of one among the following materials; carbon-composite, high-grade steel or titan.

6.

Pressure vessel according to one of the claims 1-5, **characterised in that** a gel, paste or similar is provided in the interface between the outwardly facing surface (5) of the at least one heat conducting element (2) and the internal wall (4) surface of the vessel shell (3).

7.

Pressure vessel according to one of the claims 1-6, **characterised in that** the vessel shell (3) comprises a cylindrical central part and a hemispherical part in each end.

8.

Pressure vessel according to one of the claims 1-7, **characterised in that** the vessel shell (3) is bidivided and each part comprises a flange (9) having means for securing the parts together.

9.

Pressure vessel according to one of the claims 1-8, **characterised in that** the outer wall of the vessel shell (3) on at least portions of the surface thereof is provided with cooling promoting means, like cooling fins.

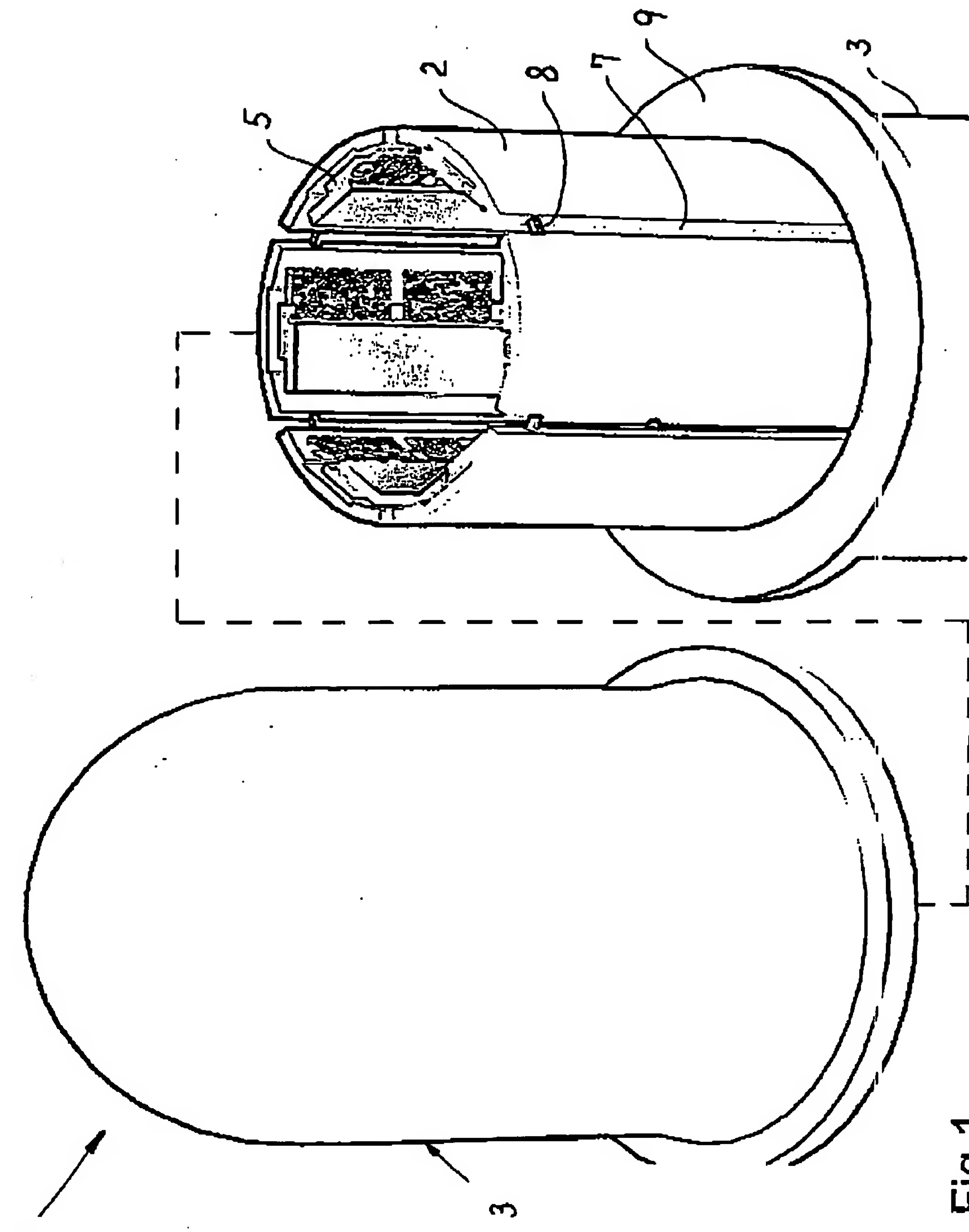


Fig.1.

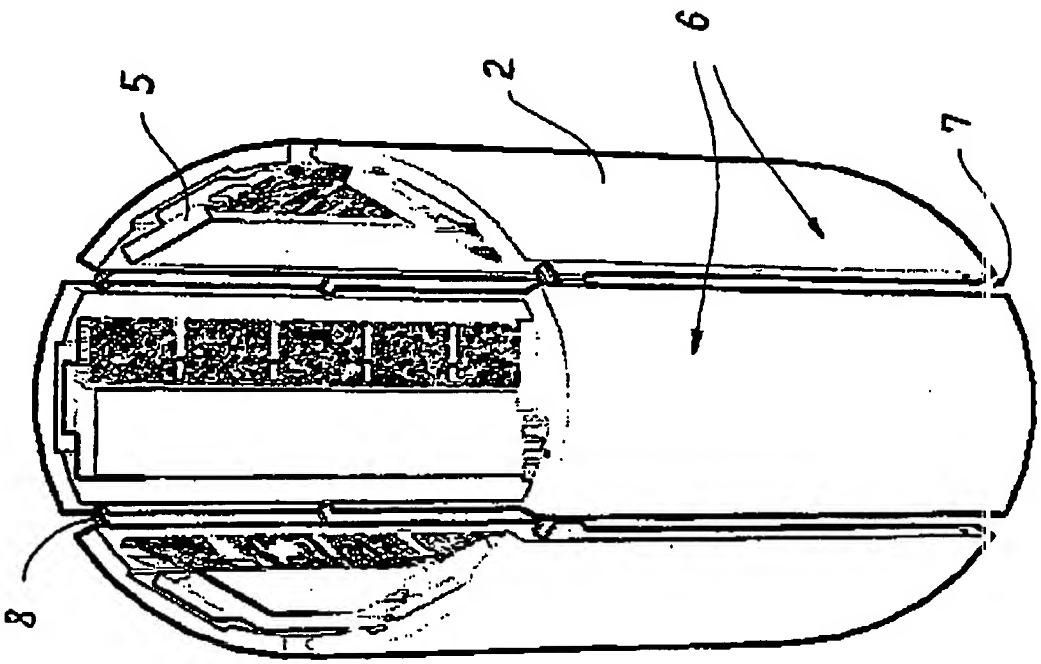


Fig.2.

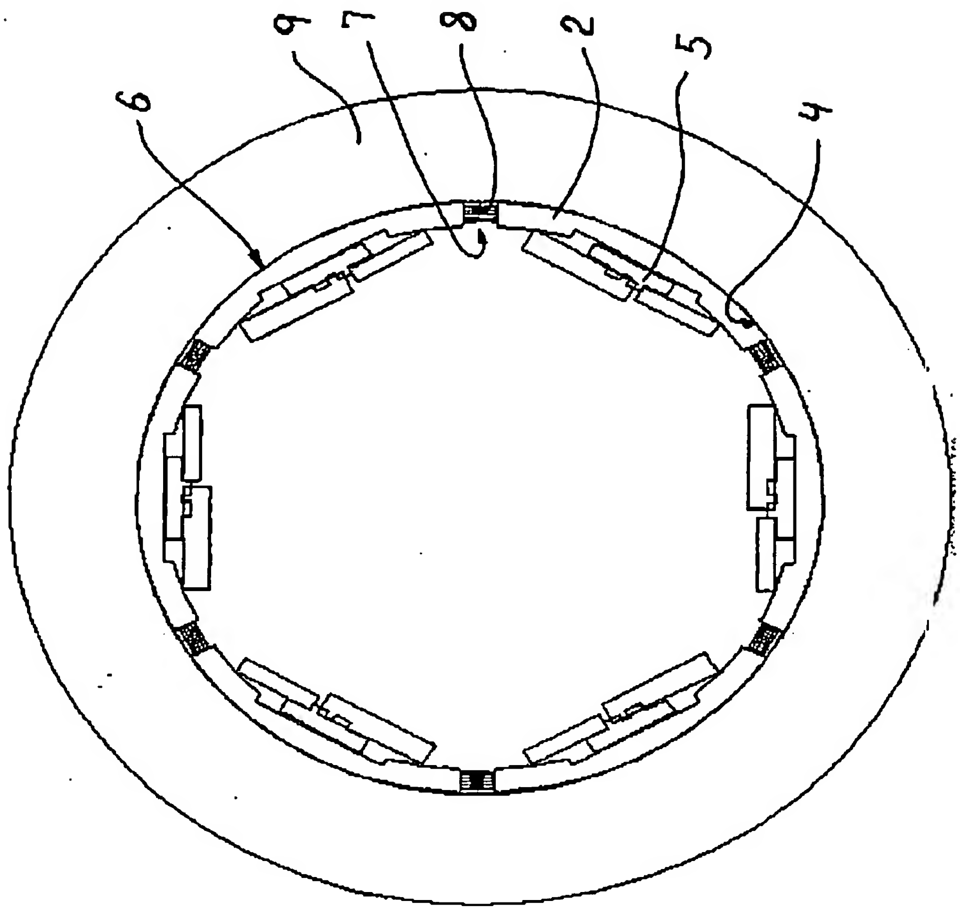


Fig.3.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO 99/00255

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H05K 7/00, H05K 7/20

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H05K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4858068 A (JEAN-PIERRE BITLLER ET AL), 15 August 1989 (15.08.89), column 2, line 7 - line 47, figure 1	1-9
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A	US 4757157 A (ANDRE PELET), 12 July 1988 (12.07.88), column 1, line 29 - line 48, figure 2	1-9
	--	
A	US 4184539 A (CHARLES R. REIN), 22 January 1980 (22.01.80), column 1, line 56 - column 2, line 18, figure 1	1-9
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☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 March 2000	20 -04- 2000

Name and mailing address of the ISA	Authorized officer
Swedish Patent Office Box 5055, S-102 42 STOCKHOLM	Fredrik Liljegren/MN

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/NO 99/00255

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4858068 A	15/08/89	FR 2596231 A,B	25/09/87
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		JP 63149923 A	22/06/88
US 4184539 A	22/01/80	NONE	